Seasonal to Interannual Variability in Antarctic Sea-Ice Dynamics, and Its Impact on Surface Fluxes and Water Mass Production

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Strong seasonal and interannual signals in Antarctic bottom-water outflow remain unexplained yet are highly correlated with anomalies in net sea-ice growth in coastal polynyas. The mechanisms responsible for driving salination and replenishment and rejuvenation of the dense shelf "source" waters likely also generate pulses of bottom water outflow. The objective of this research is to investigate time-scales of variability in the dynamics of sea-ice in the Southern Ocean in order to determine the primary sites for production of dense shelf waters. We are using a merged satellite/buoy sea-ice motion data set for the period 1978–present day to compute the dynamics of opening and closing of coastal polynyas over the continental shelf. The OCCAM ocean general circulation model with coupled sea-ice dynamics is presently forced using NCEP data to simulate fluxes and the salination impact of the ocean shelf regions. This work is relevant in the context of measuring the influence of polar sea-ice dynamics upon polar ocean characteristics, and thereby upon global thermohaline ocean circulation.

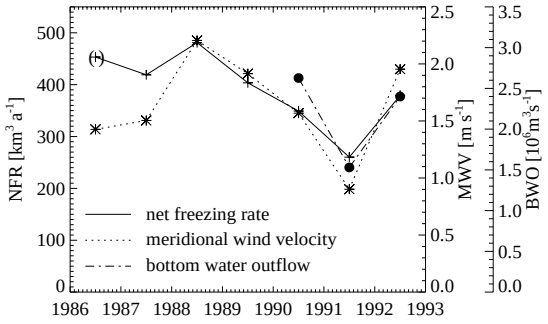

Figure. Timeseries showing relationship between annual means of model-simulated net freezing rate (NFR), meridional wind velocity (MWV), and Antarctic bottom water outflow (BWO) at Joinville Island (63.5° S, 57° W).

Interannual variability in simulated net freezing rate in the Southern Weddell Sea is shown for the period 1986–1993. There is a pronounced maximum of ice production in 1988 and minimum in 1991 in response to anomalies in equatorward meridional wind velocity. This follows a similar approximate 8-year interannual cycle in SST and satellite-derived ice-edge anomalies reported elsewhere as the "Antarctic Circumpolar Wave." The amplitude of interannual fluctuations in annual net ice production are about 40% of the mean value, implying significant interannual variance in brine rejection and upper ocean heat loss. Southward anomalies in wind stress induce negative anomalies in open water production, which are observed in passive microwave satellite images. Thus, cycles of enhanced poleward wind stress reduce ice growth by compacting the ice along the coastline and closing open water in leads and polynyas. Model simulations confirm that years of low ice production, such as 1991, coincide with years of lower than normal bottom water outflow. Future plans include the assimilation of satellite ice concentrations and ice drift dynamics, to more accurately constrain boundary conditions in the model.